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Title: FY 2013 Engineering Campaign Weapon System Engineering Assessment Technology Mid-Year Program Review

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National Nuclear Security Administration

FY 2013 Engineering Campaign
Weapon System Engineering Assessment Technology

Mid-Year Program Review

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This document is deemed unclassified by:

John R. Hartin, R&D Engineer, W-14, 03/21/13

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FY 2013 Overview – Budget ($k)

MAL/MTE/SAL/Project	Omnibus/CR	Current Funding	Costed *	Prior Year Carryover **	Projected End-of-Year Costed
1.3.2.1 LANL Methodology, Needs and Engineering Research	200	115	32	32	210
1.3.2.2 LANL Experimental Validation	1513	871	312	81	1454
Total FY13 Budget	1713	986	344	113	1664

Total Prior Year Budget	1646			134	1667

* *As of 02/28/13*
** *Before Omnibus/CR*

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FY 2013 Overview – Accomplishments

- iHATCH Phase 2
  - New sensor hardware fabricated
  - Sensor load characterization compared to high-fidelity mock
  - Characterization and optimization of optical sensor enhancement on PBX 9502 completed
  - Build of 614 assembly started in mid-March
- Explosive Response in Abnormal Thermal Environments
  - Executed 6 scaled bucket tests with PBX 9502
  - Designed and fabricated hardware for fragment impact experiments
- Abnormal Thermal Analysis
  - Preliminary results on bucket test predictions using SNL and LANL reaction kinetics models

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FY 2013 Overview – Issues/Concerns

- HE and classified geometry part fabrication is behind schedule
- Spending is behind schedule waiting for part fabrication and facility preparation
- Extreme oversubscription and high failure rates of thermal conditioning units in TA-16-301 may lead to potential overheating or experiment delay

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FY 2013 Overview – Plans for Balance

- iHATCH
  - Complete planned testing and reporting for thermal cycle testing of the mock charge.
  - Desired outcome is correlation of modeled load path with measured load path as a function of temperature
  - Remaining funding and time will begin build and test with live HE charges that were funded and should be available by 3rd quarter
- Explosive Response in Abnormal Thermal Environments
  - Complete projectile impact study and gas permeability measurements on PBX 9502
- Abnormal Thermal Analysis
  - Complete validation of bucket test modeling with comparison of SNL and LANL thermal reaction kinetics model results
  - Continue development and validation of LANL reaction kinetics model

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FY 2013 Overview – Plans for Balance

- Thermal properties of PBX 9501
  - Sample machining: Biggest issue ~6 months - looking into alternative machining options
  - Laser flash analyzer (LFA) repair: shipped for repairs, ~1 month
  - Low temperature head for LFA has been ordered
  - Behind schedule primarily due to machining issues - expect to be able to apply the necessary level of effort to complete objective when samples are machined
- APO-BMI Mechanical Properties
  - FY13 Measure the load and deflection of APO-BMI carbon syntactic foam in response to compressive loading, possibly over a range of relevant temperatures

WSEAT FY 2013
Work with Limited or No Funding

MTE/MAL/Project	Subprogram Funding Req ($k)	Req from Other Programs	Impacts to the Program / Weapon System(s)
MTE 6.2 – Failure of cases under abnormal STS environments	$500K		Will reduce risk due to case and joint changes for the B61 LEP. Multi-year funding required for risk reduction for abnormal environment case response for W78, W76, and W88
MTE 6.2 – Thermal test programmatic equipment capacity upgrades – walk-in thermal chamber for Bldg. 301	$1,000K		Additional capacity for thermal environment test on full-scale LANL component assemblies needed to support B61-LEP, W88 SFI, W88 ALT, and future W78/W88 LEP testing

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FY 2013 Level 2 Milestones Status

(Only NA-124 L2s)

ID #	Milestone Description	Current Status	Expected Year-End Status
4645	iHATCH is a multi-year program to characterize the thermal and mechanical response of insensitive high explosive materials, components, and systems by developing advanced sensing technology, data analysis techniques, and model validation protocols, and by conducting relevant component, material, and subsystem experiments. The WSEAT program supports the PCF and CMF by developing the enabling simulation and experimental technologies to validate models for assessment of insensitive explosive systems in normal, abnormal, and hostile environments	G	B

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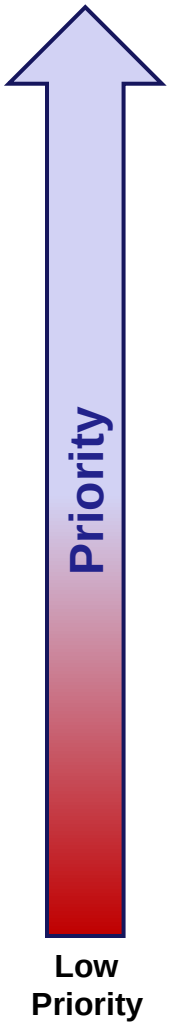
FY 2013 Project Priorities

(Includes Both Level 2 and Non-Level 2 Projects)



- iHATCH – L2 Milestone
- Explosive Response in Abnormal Thermal Environments
- Abnormal Thermal Analysis
- Thermal properties of PBX 9501
- APO-BMI Mechanical Properties

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FY 2013 Project Dependencies

Internal Dependencies	Description	Issues
Enhanced Surveillance – C8	• C8 supports HE testing and constitutive model development for PBX 9502 and PBX 9501 for improved validation data	• None

External Dependencies	Description	Issues
B61 LEP	• B61 LEP is supporting iHATCH Phase 1 analysis and sensor development for optical fiber applications on PBX 9502 for Phase 2 tests	• None
W88 SFI	• W88 is indirectly supporting sensor development for optical fiber and strain gage applications on HE that will be useful for future testing	• None

iHATCH Phase 2 in FY 13

- Newly developed iHATCH load sensor will be integrated into primary level component assemblies for in-situ load and displacement measurements at Stockpile-to-Target Sequence thermal environments.
- Experiments will assess the effects of creep and ratchet growth in high fidelity, highly confined weapon geometry.
- Resulting load-displacement data sets generated will be used to validate the normal thermal environment models being developed for the B61 LEP thermal qualification.
- Continuing effort into FY14 with live IHE assemblies will support model validation for new IHE models, characterization of new primary materials, ongoing sensor improvements, generation of data for Quantification of Margin and Uncertainty (QMU), and generation of data to complete thermal/mechanical qualification for the B61 LEP.
- Revised baseline schedule for second half of FY 13
  - Optical fiber enhancement tests on PBX 9502 are complete and data is being evaluated
  - Planned assembly start with mock IHE– April 1
  - Planned thermal cycling tests with mock IHE– week of April 29-May 3
  - Disassembly, evaluation, data analysis, reporting – complete Sept 30 (L2 Milestone)
  - Live IHE part completion – mid May
  - Planned baseline thermal cycling tests with live IHE assembly by end of FY

Modeling Thermal response of PBX 9502

Scope of Work

Motivation:

Develop a model of ignition based on LANL secondary explosive kinetics

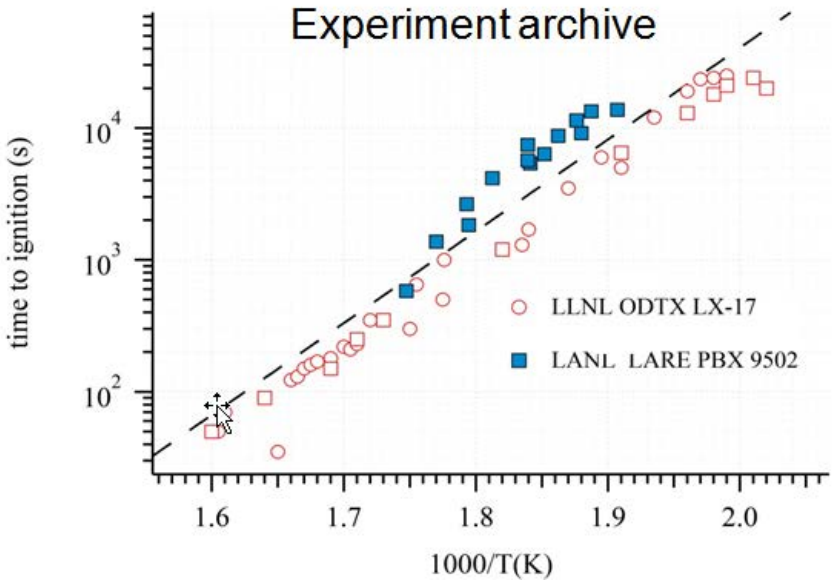
Observe thermal decomposition and burning using x-ray radiography

Deliverables:

- Transition ignition model to W-13

FY13 Accomplishments

- Preliminary pre-ignition radiography experiments on PBX 9502
- Continue implementation of thermal ignition model for PBX 9502
- Continued progress on theoretical foundation for the solid state decomposition mechanism
- First observations of conductive burning in low density PBX 9502



Measured time to ignition as a function of the inverse of the boundary temperature for PBX 9502 measured in our lab at LANL and at LLNL

Future Plans

- Continue Radiographic experiments
- Design high expansion, porosity measurements
- Determine effect of porosity on radiography
- Determine effect of permeability on internal burning

Modeling Progress

Midyear FY13 progress primarily involves new thermal explosion experiments on PBX 9502, where spatially resolved internal temperatures were measured and dual axis x-ray radiography images obtained as 1 to 100 Hz movies in the final minutes of thermal runaway leading to ignition.

Preliminary conclusions include

1) The model of thermal ignition is in good agreement with experiments at 248, 250 and 252 C radial boundary temperature
2) The model continues to rise in temperature less steeply than experiments, but we are developing hypothesis concerning graphite formation upon decomposition
3) Internal temperature rise does not appear to be driven by sublimation in fully pressed samples, consistent with the lack of permeation
4) We have observed conductive burning with measured velocity, in low density PBX 9502 for the first time

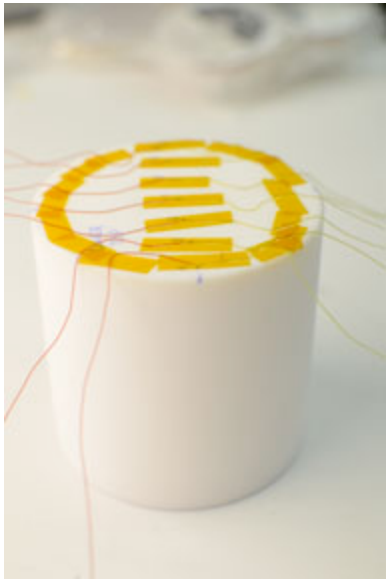
Abnormal Thermal Test Summary

- Task I - Permeability of PBX 9502. C6 funding = $75k Conducted planning for this project, but have not advanced to the testing stage. The HE parts fabrication will likely be the limiting step. Currently, they are scheduled to be fabricated sometime in August. It will be challenging to complete this task this fiscal year unless HE fabrication schedule is conservative and parts are available sooner.

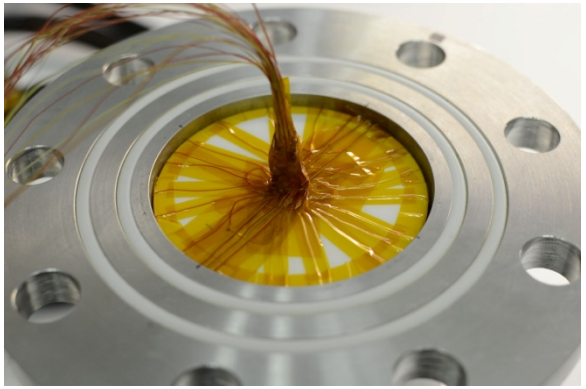
- Task II - Fragment Impact into Hot PBX 9502. C6 funding = $75k Philip Rae is leading this effort. He has designed and fabricated the target casing, the gun barrels have arrived, and interferometer parts are on order. The IWD for testing has been signed. The PBX 9502 cylinders are also complete. Several other parties are interested in fragment impact and they are in the process of choosing projectile geometries for testing.

- Task III - IHE Thermal. C6 funding = $100k Six pressure-variable, scaled bucket cook-off tests were completed this quarter with high quality data acquired. A report on these test results is about 50% complete. The pressure and temperature data have already been made available and are being used by Advanced Engineering Analysis to develop a robust pressure dependent cook-off model for PBX 9502. Additionally, HE and metal parts fabrication is complete for two follow-up DDT tests. It is anticipated that the DDT experiments will be performed during the April-May timeframe.

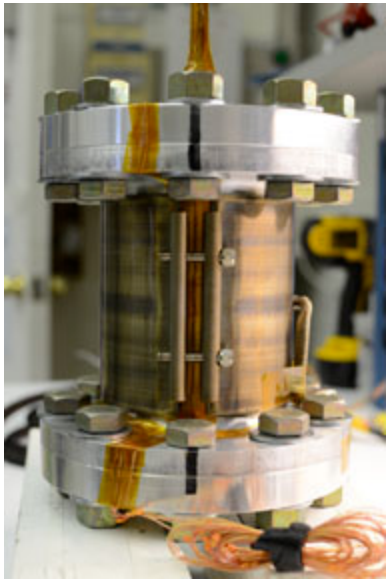
Cookoff Bucket Assembly



Thermocouples attached on the midplane with kapton tape



Bucket loaded with cylindrical charge. Thermocouple wires are bundled and routed for the feedthrough.



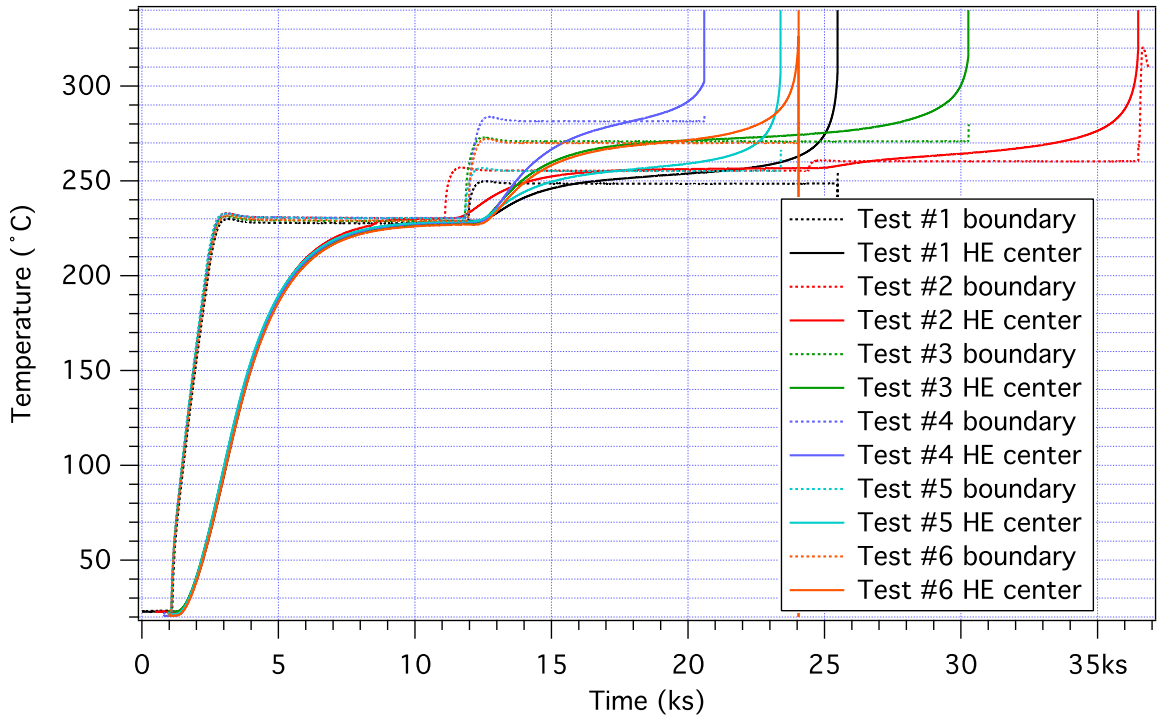
Assembled bucket with band heater attached

With insulation

Slide 16

Results Overview

- 6 tests completed – all successful
- All were similarly low violence, despite variation in pressure, temperature and duration



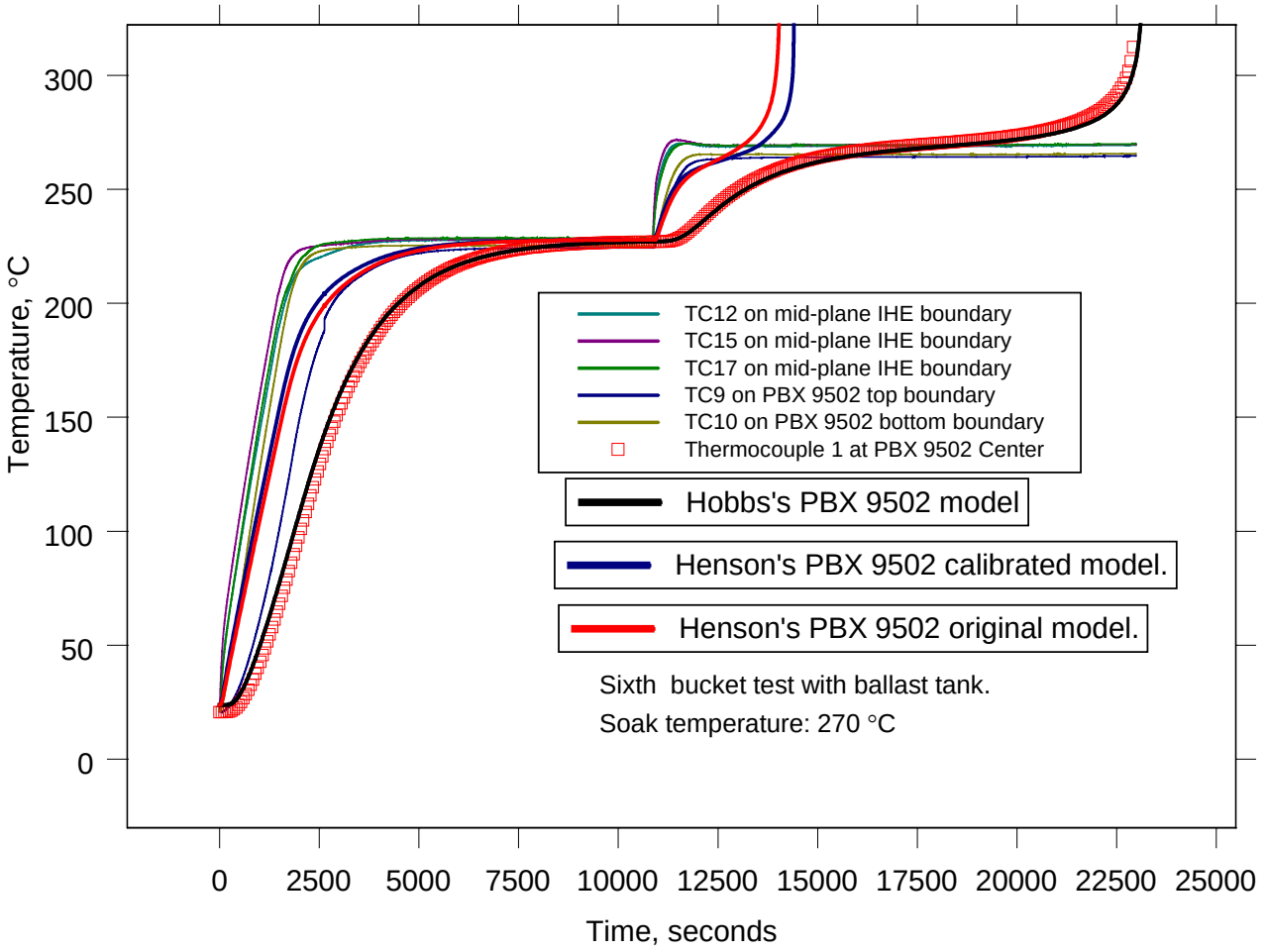
Slide 17

Results – Test #4, High-speed video stills

- Luminous combustion ignites in product gas plume jetting from open ports in lid (see 2nd frame). Ignition jumps suddenly to inside.
- Non-violent, unsteady burn of PBX 9502
- Casing is recovered nearly intact, NPT fittings were only component failure
- Thermal runaway centers
- Thermocouple data are excellent quality, with high spatial resolution describing the evolution of the thermal field

Results – Test #6, Internal thermocouples Thermal runaway stage

Comparison of Hobbs's and Henson's models with center thermocouple for bucket test # 6. For this case Henson's model doesn't predict the ignition location correctly.



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Backup

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FY 2013 Risk

Risk Description	Impact	Specific Mitigation Strategies
Load measuring sensor does not provide accurate measurement of load path in B61 primary	This technology was planned as a tool to evaluate impact of new component designs on the MOD 12 load path through the primary. Loss of this capability hurts the ability to assess design changes.	Other sensor technologies such as MEMS-based strain sensors or eddy current sensors may provide alternate techniques
Optical fiber enhancement techniques fail to provide accurate and repeatable gap data for PBX 9502	Incomplete or inaccurate gap data from the iHATCH Phase 2 experiments could mean loss of load path and deflection data for Mod 12 design changes	Other sensor technologies such as MEMS-based strain sensors or eddy current sensors may provide alternate techniques
Constitutive and thermal decomposition models for PBX 9502 may not prove adequate	Fully validated system models may not exist for all environments of interest especially for abnormal thermal and mechanical scenarios where predictive capability is not possible	A test series consisting of component level local tests and joint system tests will provide qualification evidence for confidence in component and system performance

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FY 2013 Level 2 Milestones Status

(Only NA-124 L2s)

Milestone 4645: iHATCH is a multi-year program to characterize the thermal and mechanical response of insensitive high explosive materials, components, and systems by developing advanced sensing technology, data analysis techniques, and model validation protocols, and by conducting relevant component, material, and subsystem experiments. In FY13, iHATCH Phase 2 is developing new sensing technology to measure the load path in situ in a B61 primary assembly.

Due: 09/30/2013

Current Status:  Expected Year-end Status: 

Major Accomplishments

- Sensor hardware design, fabrication, and component level testing complete. Primary assembly scheduled April 2013. Thermal test complete for mock assembly by May 2013. Budget permitting, a live IHE assembly test will be conducted to provide baseline data.

Issues

- None

Subprogram Outyears (FY 2014-2019) Budget ($k)

MTE/SAL/Project	FY14 Reqt	FY15 Reqt	FY16 Reqt	FY17 Reqt	FY18 Reqt
1.3.2.1 LANL Methodology, Needs and Engineering Research	735,065	725,744	740,401	773,388	788,856
1.3.2.2 LANL Experimental Validation	3,468,885	3,577,350	3,612,525	3,682,875	3,756,533
Total	**4,203,950**	**4,303,094**	**4,352,926**	**4,456,263**	**4,545,388**

* Risk detail located in backup

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Outyears (FY 2014-2019) Scope

- MTE 6.1 – Methodology, Needs, and Engineering Research
  - PBX 9502, LX07, and XTX reaction kinetics model development and supporting fundamental experimentation
  - Constitutive model development for thermal/mechanical response of PBX 9502 to normal environments including ratchet growth and contour change characterization
  - Diagnostics development for component level abnormal environment experiments (e.g. Digital Image Correlation)
- MTE 6.2 – Experimental Validation
  - B61 LEP Normal Thermal model validation experiments – continuation of iHATCH Phase 2 experiments with DEV and PPI hardware to verify new load path and modeling capability
  - B61 LEP Abnormal Thermal testing at intermediate and full scale geometry
  - W88 Alt dynamic testing to verify response of aged system to hardware changes
  - W76/W78/W88 case joint failure modeling and experiments